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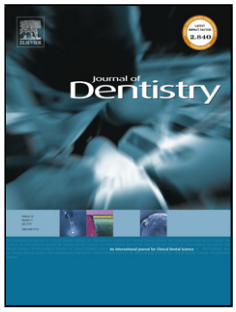

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TITLE PAGE

THE RELATIONSHIP BETWEEN DENTINE HYPERSENSITIVITY, DIETARY ACID INTAKE AND EROSIVE TOOTH WEAR.

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Short title: Diet, hypersensitivity and tooth wear

Key terms: Dentine Hypersensitivity, Diet, Toothbrushing, Tooth Wear, Tooth abrasion, Epidemiology

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ABSTRACT

Objectives: To assess the interplay between dietary acid intake, toothbrushing and erosive tooth wear as aetiological factors in self-reported DH

Materials and Methods: This is a secondary analysis on previously collected data from 600 participants with (n=300) and without (n=300) severe erosive tooth wear. Participants recruited from restorative clinics of King's College London Dental Institute (REC Ref 14/EM/1171) were questioned on their self-reported DH, frequency and timing of dietary acid intake, habits associated with consumption of dietary acids and tooth brushing habits. Erosive tooth wear was assessed using Basic Erosive Wear Examination (BEWE). Differences in diet and brushing habits between those with self-reported DH and those without were analysed using descriptives and logistic regression in SPSS vers. 24.

Results: Of those reporting with DH (n=272), a greater number spent ≥10min eating fruit per sitting, (n=46) and had a drinking habit such as sipping, swishing or holding drinks in the mouth (n=72) compared to those without DH (n=26 OR 2.72, 95%CI [1.32-5.61], p=0.007 and n=38 OR2.33, 95%CI [1.40-3.88], p=0.001, respectively). More DH participants used a soft toothbrush (n=36) compared to those without DH (n=18 OR 2.35, 95%CI [1.20-4.59], p=0.013). No association was observed with frequency of daily toothbrushing or dietary acid intake.

Conclusion: Contact time between the tooth and the acid may be a more important risk factor for DH compared to frequency of dietary acid intake or frequency of toothbrushing. Other possible aetiological factors should be considered.

Clinicaltrials.gov number: NCT02449434

Clinical Significance: Increased contact time with dietary acids and sipping swishing or holding drinks in the mouth prior to swallowing should be addressed as an aetiological factor in DH. Toothpaste abrasivity and toothbrush filament stiffness may play a greater role in DH compared to frequency of toothbrushing.

INTRODUCTION

Dentine hypersensitivity is a common, painful oral condition which has been characterised as an intense, transient pain resulting from exposed dentine, typically in response to chemical, thermal, tactile or osmotic stimuli [1]. Dentine tubules must be patent for dentine hypersensitivity to occur [2] and it has been observed in vitro that dietary acids can remove the smear layer exposing dentinal tubules [3]. Dietary acid intake has been associated with dentine hypersensitivity [1,4,5], with one clinical trial reporting a relationship between dietary acid intake in the previous hour and a positive response to clinical dentine hypersensitivity testing [6].

Dietary acids have also been associated with erosive tooth wear [4,7]. It was recently observed in a case-control study on 600 participants, that patients presenting with dietary erosive tooth wear were more likely to present with self-reported dentine hypersensitivity ($p<0.001$)[4]. However, a large proportion of those without wear (41.7%) also reported to have dentine hypersensitivity [4]. It is not understood what specific risk factors from the diet results in dentine hypersensitivity. It could be the behavioural characteristics related to dietary acid consumption or the diet itself.

Furthermore, there is a lack of clinical data on the relationship between brushing habits and dentine hypersensitivity. Brushing factors such as brushing force and different toothpastes have been observed to affect tubule patency in vitro [8–10]. However, the largest epidemiological study to date investigating dentine hypersensitivity on 3,187 participants observed no relationship between brushing frequency, the type of toothbrush used (manual or electric) or brushing movement. No clear relationship was observed between dentine hypersensitivity and the timing of brushing in relationship to meals [1].

The aim of this analysis was to investigate the association between dentine hypersensitivity, dietary acid intake patterns and tooth brushing habits. The null hypothesis proposed that there will be no difference in dietary acid intake patterns and tooth brushing habits between those with self-reported dental hypersensitivity symptoms and those without.

MATERIALS AND METHODS

This study is based on secondary analysis of previously collected data, a full description of which is presented in O'Toole et al., 2017 [4]. Briefly, 600 adults aged 18 years or older (300 cases with severe erosive tooth wear and 300 controls frequency-matched by age) were recruited from restorative clinics of Guy's Hospital, King's College London Dental Institute (Research Ethics Committee Reference 14/WS/0015, Clinical Trials Identifier number NCT02449434) between the period May 2014 and March 2016. Participants had a minimum of 10 teeth in each jaw with no missing anterior teeth, anterior crowns, bridges, active caries or periodontal disease and were diagnosed by their treating practitioner as having moderate-severe erosive tooth wear or no-mild erosive tooth wear. Those with potential acid sources for intrinsic erosive wear, xerostomia bruxism, pregnancy, involvement in other research or inability to speak or understand in English were excluded. Erosive tooth wear cases were defined as those with a Basic Erosive Wear Examination (BEWE) score of 12 or higher and at least one score of 3 in a sextant (clinically classified as moderate to severe erosive tooth wear), whereas controls were defined as those with a BEWE score of 10 or lower and no score of 3 on any surface of any tooth (clinically classified as no or mild erosive tooth wear).

Once accepted, a trained interviewer questioned participants on tooth hypersensitivity, toothbrushing habits and acidic intake using an adapted version of a previously validated questionnaire [4]. Dentine hypersensitivity was measured with a single question (yes/no) and used as the outcome measure for this study. Toothbrushing habits referred to the daily frequency of brushing (once a day or less often, twice a day and 3 or more times a day) type of toothbrush used (powered, soft, medium and hard manual), use of desensitising toothpaste and brushing within 10 min of consuming something acidic. Dietary habits referred to daily frequency intake of acid fruits (apples, citrus, grapes, berries and any other fruit) and acidic drinks (carbonated drinks, fruit drinks, any other acidic drinks e.g. fruit teas, wine) with meals and between meals, the duration of each dietary acid intake (<5, 5-10 and >10 min), and any drinking habits prior to swallowing (such as sipping, swishing or holding the drink in the mouth). On average, questionnaires were completed between 5 and 10 min.

Statistical analysis

We first compared the proportion of patients with self-reported dentine hypersensitivity by demographic (gender and age), clinical (presence of erosive tooth wear) and behavioural characteristics (brushing habits and acidic intake) using the Chi-squared test. The crude and adjusted association between brushing habits and acidic intake with dentine hypersensitivity was assessed using binary logistic regression models using presence/absence of self-reported dentine hypersensitivity as the outcome variable. Odds ratios (OR) were thus reported as the measure of association. The adjusted model controlled for demographic, presence of erosive tooth wear and clinical factors. Significance was inferred at $p<0.05$.

RESULTS

The mean age of participants was 44 (SD: 14, range: 18-83), with 313 (52.1%) women and 287 (47.9%) men. Two hundred and seventy-two participants (45.3%) self-reported as having dentine hypersensitivity. Dentine hypersensitivity was significantly more common among women, younger adults and those with severe erosive tooth wear (Table 1).

In terms of brushing habits (Table 1), a greater number of those reporting dentine hypersensitivity used a soft toothbrush (n=36) compared to those without dentine hypersensitivity (n=18; p=0.012). There were no significant differences with daily frequency of brushing (p=0.656), time spent brushing (p=0.258) and whether the patient brushed within 10 minutes of consuming a dietary acid (p=0.158).

As for dietary acid intake (Table 2), there was a positive trend in dentine hypersensitivity by intake of acidic drinks between meals. Dentine hypersensitivity was more common among participants consuming ≥ 3 dietary acids between meals daily than those without sensitivity (53% versus 47%, p=0.002) and those that drank ≥ 2 acidic drinks between meals (54.9% versus 43.2%, p<0.001). No differences were found in dentine hypersensitivity by daily intake of acidic drinks with meals (p=0.917) and time spent during consumption of acidic drinks (p=0.619). Dentine hypersensitivity was more common among participants with the habit of sipping, swishing or holding drinks in the mouth prior to swallowing (65.5%) than those with habits without dentine hypersensitivity (34.5%),

p<0.001. A greater number of those with dentine hypersensitivity spent ≥ 10 min per sitting eating fruit (63.9%) compared to those without dentine hypersensitivity (36.1%), p=0.005.

In the multivariate analysis (Table 3), an association was observed between presence of severe erosive tooth wear and self-reported dentine hypersensitivity (OR 1.64, 95% CI 1.05-2.58, p=0.03). Females were more likely to report dentine hypersensitivity (OR 1.76, 95% CI 1.22-2.54, p=0.002). A general trend was observed that reporting of dentine hypersensitivity decreased with age but this was only statistically significant for those over the age of 66 (OR 0.16, 95% CI 0.06-0.43, p<0.001). The use of a soft tooth brush increased the likelihood of self-reported dentine hypersensitivity (OR 2.35, 95% CI 1.20-4.59, p=0.013). Associations with dentine hypersensitivity were also observed when greater than 10 minutes was spent eating fruit at a sitting daily (OR 3.03, 95% CI 1.64-5.61, p<0.001). No relationship was observed between frequency of dietary acidic drink intake between meals and dentine hypersensitivity when other factors were controlled for.

DISCUSSION

This study provides unique insights into the inter-relationship between dietary acid intake, erosive tooth wear and presence of self-reported dental hypersensitivity. An association between diet and dentine hypersensitivity was observed when greater than 10 minutes was spent consuming fruit at a single sitting (OR 3.03, 95% CI 1.64-5.61, p<0.001) and the presence of a habit such as sipping swishing or holding the drinks in the mouth (OR 2.33, 95% CI 1.40-3.88, p=0.001). This was independent of the frequency of dietary acid intake and may suggest that contact time with dietary acids may be the driving component in the dentine hypersensitivity pathological process. The presence of erosive tooth wear increased the odds of presenting with dentine hypersensitivity in this study (OR 2.30, 95% CI 1.22-4.32, p=0.01) and confirms other studies [1,7,10]. In contrast to risk factors for erosive tooth wear [4], no relationship was observed between frequency of dietary acid intake between meals and self-reported dentine hypersensitivity when other factors were fully controlled for. This may be one of the explanatory factors why patients may present with dentine hypersensitivity but not erosive tooth wear and vice versa. Despite this difference, there are

commonalities between the aetiology of dentine hypersensitivity and erosive tooth wear and similar prevention messages could be targeted at both.

The frequency of daily tooth brushing and time spent brushing teeth was unrelated to dentine hypersensitivity in this study. This supports the pan-European study reporting limited associations between dentine hypersensitivity and brushing habits [1] and other epidemiological studies [11,12]. There are conflicting studies that have observed increased frequency of tooth brushing to be associated with dentine hypersensitivity [13,14]. However, there are differences in the analysis of frequency of tooth brushing. Some authors [1,4,11,12] have compared the norm of brushing twice daily to increased frequency of brushing (3+ times daily), whereas other epidemiological studies have compared once or less daily brushing (below the recommended frequency) to 2+ times daily [13,14] which should be emphasised. In our study and others, most participants reported to brush their teeth twice daily and no differences were observed regardless of the analysis of frequency of brushing. Interestingly, the presence of self-reported dentine hypersensitivity was associated with the use of a soft toothbrush (OR 2.16 (95% CI 1.05-4.42, p=0.035). Bizhang *et al.* 2016 observed that soft bristled toothbrushes caused more abrasive dentin wear in vitro than hard bristled toothbrushes and proposed that softer filament toothbrushes retain more dentifrice [15]. Lippert *et al.* 2017 in a comprehensive, in vitro study on bristle stiffness and toothpaste abrasivity on both enamel and dentin concluded that bristle stiffness was a secondary factor in the wear process with tooth paste abrasivity being the primary risk factor for abrasive wear [16]. Another in vitro study observed tooth brushing force to be the primary risk factor for dentine tubule occlusion [8]. There is great difficulty in assessing these variables in vivo. All are subject to reporting bias or the hawthorne effect if observed clinically. A further potential confounding factor in this study is those with dentine hypersensitivity or erosive tooth wear may have been advised by their health care professional to use a soft toothbrush. Further interventional studies are required before a particular type of tooth brush is recommended to patients with dentine hypersensitivity.

The limitations of this study need to be addressed. Those with periodontal disease were excluded from this study and we did not measure gingival recession in either group. Gingival recession has been

consistently associated with dentine hypersensitivity [13,14] and this may have influenced the outcome. Furthermore, this is a secondary analysis on data where the original study design increased the number of erosive tooth wear cases in the study population. However, clinical erosive tooth wear was controlled for in the regression analysis. Interestingly, the 45% prevalence of dentine hypersensitivity observed in this study population is not very different to the prevalence of self-reported dentine hypersensitivity in the general population (42%) [1]. The aim of this study was to investigate self-reported sensitivity alongside clinical screening for erosive tooth wear. Unfortunately, it was not feasible to clinically validate dentine hypersensitivity and all measures reported in this study apart from clinical erosive wear are self-reported. Some investigators have recommended that you use two methods to diagnose dentine hypersensitivity [17] and the use of one method is not ideal. However a large epidemiological study investigated three methods of dentine hypersensitivity testing and observed all methods, including self-reported dentine hypersensitivity, to correlate strongly with each other [1]. Finally, this study was based on a convenient sample of hospital volunteers, which may limit the generalisability of these findings.

Having stated these limitations, the results of this study support the findings that an acidic diet is associated with dentine hypersensitivity. The association was particularly strong when participants had dietary habits which increased the intraoral exposure time of the dietary acid. Although interventional studies are needed to establish causation, addressing this risk factor may help to reduce symptoms in those presenting with dentine hypersensitivity.

CONCLUSION

A relationship was observed between prolonged consumption of dietary acids, erosive tooth wear and self-reported dentine hypersensitivity. Presentation with self-reported dentine hypersensitivity may be an indication of an acidic diet and addressing this may alleviate self-reported dentine hypersensitivity symptoms and protect against erosive tooth wear progression. No clear relationship was observed between tooth brushing behaviours and dentine hypersensitivity.

Conflicts of Interests and Sources of Funding

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TABLE 1: CRUDE ANALYSIS OF SELF-REPORTED DENTINE HYPERSENSITIVITY WITH DEMOGRAPHICS AND TOOTH BRUSHING HABITS

Variable	No hypersensitivity n=328 n (%)	Hypersensitivity n=272 n (%)	p value
Outcome			<0.001*
Severe erosive tooth wear	134 (40.9%)	166 (61.0%)	
Mild/Moderate erosive tooth wear	194 (59.1%)	106 (39.0%)	
Age			0.001*
18-25	30 (9.1%)	34 (12.5%)	
26-35	66 (20.1%)	68 (25.0%)	
36-45	71 (21.6%)	63 (23.2%)	
46-55	68 (20.7%)	64 (23.5%)	
56-65	53 (16.2%)	35 (12.9%)	
66+	40 (12.2%)	8 (2.9%)	
Gender			0.001*
Female	151 (46%)	162 (59.6%)	
Male	177 (54%)	110 (40.4%)	
Do they use a de-sensitising toothpaste?			<0.001*
No	252 (76.8%)	97 (35.7%)	
Yes	76 (23.2%)	175 (64.3%)	
Type of toothbrush			0.012*
Soft manual tooth brush	18 (5.5%)	36 (13.2%)	
Medium manual tooth brush	144 (43.9%)	107 (39.3%)	
Hard manual tooth brush	21 (6.4%)	17 (6.3%)	
Electric tooth brush	145 (44.2%)	112 (41.2%)	
Time spent brushing teeth			0.258
> 2min	257 (78.4%)	224 (82.4%)	
< 2min	71 (21.6%)	48 (17.6%)	
Does the patient brush immediately after having something acidic?			0.158
No	253 (77.1%)	196 (72.1%)	
Yes	75 (22.9%)	76 (27.9%)	
Frequency of daily brushing			0.656
≤1 daily	49 (14.9%)	34 (47.7%)	
2/day	257 (78.4%)	221 (81.3%)	
3+/day	22 (6.7%)	17 (6.3%)	

* indicates significance

TABLE 2: CRUDE ANALYSIS OF SELF-REPORTED DENTINE HYPERSENSITIVITY AND DIETARY ACID INTAKE

Variable	No hypersensitivity n=328 n (%)	Hypersensitivity n=272 n (%)	p value
Total daily acid intake			0.257
1 or less daily	54 (16.5%)	33 (12.1%)	
2/day	69 (21%)	54 (19.9%)	
3 or greater/day	205 (62.5%)	185 (68.0%)	
Acid intake with meals			0.917
1 or less daily	218 (66.5%)	177 (65.1%)	
2/day	63 (19.2%)	53 (19.5%)	
3 or greater/day	47 (14.3%)	42 (15.4%)	
Acid intake between meals			0.002*
1 or less daily	131 (39.9%)	74 (27.2%)	
2/day	80 (24.4%)	66 (24.3%)	
3 or greater/day	117 (35.7%)	132 (48.5%)	
Total daily acidic drink intake			0.019*
0	108 (32.9%)	70 (25.7%)	
1/day	91 (27.7%)	64 (23.5%)	
2 or greater/day	129 (39.3%)	138 (50.7%)	
Drinks with a meal			0.080
0	194 (59.1%)	142 (52.5%)	
1/day	88 (26.8%)	74 (27.2%)	
2 or greater/day	46 (14.0%)	56 (20.6%)	
Drinks between meals			0.001*
0	157 (47.9%)	100 (36.8%)	
1/day	95 (29.0%)	72 (26.5%)	
2 or greater/day	76 (23.2%)	100 (36.8%)	
Sips, swishes or holds acidic drinks			<0.001*
Does not drink acidic drink			
Drinks acidic drink no habit	108 (32.9%)	70 (25.7%)	
Habit	182 (55.5%)	130 (47.8%)	
	38 (11.6%)	72 (26.5%)	
Duration of each acidic drink intake			0.619
No intake			
<5mins	42 (12.8%)	33 (12.1%)	
5-10 mins	87 (26.5%)	62 (22.8%)	
>10mins	47 (14.3%)	47 (17.3%)	
	152 (46.3%)	130 (47.8%)	
Total daily fruit intake			0.650
0	51 (15.5%)	47 (17.3%)	
1/day	96 (29.3%)	71 (26.1%)	
2 or greater/day	181 (55.2%)	154 (56.6%)	
Fruit intake with meals			0.196
0	190 (57.9%)	175 (64.3%)	
1/day	91 (27.7%)	69 (25.4%)	
2 or greater/day	47 (14.3%)	28 (37.3%)	
Fruit intake between meals			0.194
0	97 (29.6%)	72 (26.5%)	
1/day	116 (35.4%)	85 (31.3%)	
2 or greater/day	115 (35.1%)	115 (42.3%)	
Duration of each fruit intake			0.005*

No daily intake	39 (11.9%)	33 (12.1%)
<5 min	232 (70.7%)	164 (60.3%)
5-10 min	31 (9.5%)	29 (10.7%)
>10 mins	26 (7.9%)	46 (16.9%)

* indicates significance

TABLE 3: REGRESSION MODEL USING PRESENCE OF SELF-REPORTED DENTINE HYPERSENSITIVITY AS THE DEPENDENT VARIABLE.

Variable	OR	95% CI	p value
Presence of erosive tooth wear			0.030*
Mild/Moderate erosive tooth wear	1		
Severe erosive tooth wear	1.64	(1.05-2.58)	
Age			
18-25	1		
26-35	0.94	(0.49-1.80)	0.859
36-45	0.82	(0.43-1.56)	0.536
46-55	0.91	(0.48-1.73)	0.768
56-65	0.61	(0.30-1.23)	0.166
66+	0.16	(0.06-0.43)	<0.001*
Gender			0.002*
Male	1		
Female	1.76	(1.22-2.54)	
Type of toothbrush			
Medium manual tooth brush	1		
Soft manual tooth brush	2.35	(1.20-4.59)	0.013*
Hard manual tooth brush	0.83	(0.40-1.76)	0.631
Electric tooth brush	1.01	(0.69-1.48)	0.952
Drinks between meals			
0	1		
1/day	0.86	(0.49-1.51)	0.592
2 or greater/day	1.36	(0.75-2.46)	0.306
Sips, swishes or holds acidic drinks (habit)			0.001*
Drinks acidic drink no habit	1		
Habit	2.33	(1.40-3.88)	
Duration of each fruit intake			
<5 min	1		
5-10 min	1.32	(0.56-2.18)	0.368
>10 min	3.03	(1.64-5.61)	<0.001*